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AUTHOR(S): Joseph N(atale) Ginocchio, T-5

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Joseph N. Ginocchio
Theoretical Division, Los Alamos National Laboratory
Los Alamos, NM 87545

ABSTRACT

The expectation value of the spin operator in the SO_8 and SP_6 models is studied.

1. INTRODUCTION

The SO_8 and SP_6 models[1] assume that the low-lying collective states of heavy nuclei are dominated by collective pairs of fermions coupled to angular momentum $J^\pi = 0^+, 2^+$. These models are generalizations of the pairing model (SP_2) to include the quadrupole degree of freedom. Within these models, the total shell model space can be classified in terms of the number of nucleons u not coupled to angular momentum zero or two. This classification follows from partitioning the single-particle angular momentum $\vec{j}$ into psuado-orbital angular momentum $\vec{k}$ and psuedo-spin $\vec{i}$. For shell model orbitals for which $k = 1$ the generators of SP_6 are the multipole and pair operators that have pseudo-spin coupled to zero. For shell model orbitals with $i = 3/2$ the generators of SO_8 are the multipole and pair operators that have pseudo-orbital angular momentum coupled to zero. In this paper we focus on the SO_8 model.

2. SPIN IN THE COLLECTIVE SUBSPACE

The spin $\vec{S}$ operator can be expanded in the k-i basis from the j-j basis,

$$\vec{S} = \sum_{K,I} C(K,I)\ (b^{\dagger}_{ki}\tilde{b}_{ki})^{(K,I)} \tag{1}$$

where $b^{\dagger}_{km,in}$ creates a particle in the k-i orbit with psuedo-orbital angular momentum projection m and psuedo-spin projection n, $(\ )^{(K,I)}$ means coupled to total psuedo-orbital angular momentum K and total psuedo-spin I, and the coefficients C(K,I) are given by,

$$C(K,I) = \sum_{j,j'} \frac{\langle j \,||\, \vec{S} \,||\, j' \rangle}{\sqrt{3}}\ \hat{j}'\hat{j}\ \hat{K}\ \hat{I} \begin{Bmatrix} k & k & K \\ i & i & I \\ j & j' & 1 \end{Bmatrix}, \tag{2}$$

where $\hat{j} = \sqrt{2j+1}$. We can rewrite this expression for the spin operator as

$$\vec{S} = q\ \vec{I} + \sum_{I,K\neq 0} C(K,L)\ (b^{\dagger}\tilde{b})^{(K,I)} \tag{3}$$

where q is the quenching factor and is given by

$$q = \sqrt{(2/5\Omega)}\ C(K=0, I=1)\ . \tag{4}$$

For the SO_8 model the collective subspace made up only of $J^{\pi} = 0^+, 2^+$ pairs only; i.e., u = 0, has K = 0. Hence within this subspace only the first term in (4) contributes, and furthermore J = I. Thus the expectation value of the spin in the collective u = 0 subspace depends only on q. We can derive a simple expression for q for heavy nuclei (i.e., the maximum angular momentum j is ℓ - 1/2 where ℓ is the real angular momentum). We get

$$g = \frac{1}{15}\left[-1 + \left[\frac{4}{\Omega}\right]^2 \pm 2\sqrt{(1 - \left|\frac{2}{\Omega}\right|^2)(1 - 2\left[\frac{2}{\Omega}\right]^2)}\right] \tag{5}$$

where $\Omega = \Sigma\ (2j+1)$ is one half the shell degeneracy. The two signs arise from phase freedom in going from k-i (or i-k coupling) to the j-j basis. Since the SO_8 algebra is invariant to unitary transformations, we can change the sign of the single-particle basis and leave the algebra invariant. This doesn't effect any diagonal matrix elements in the j-j basis, only off-diagonal matrix elements. The resulting q factors are given in Table 1.

Ω	q_+	q_-	q_j			
			j $\frac{1}{2}$	$\frac{3}{2}$	$\frac{5}{2}$	$\frac{7}{2}$
6	0.074	- 0.148	-0.333,	0.333,	-0.143	
10	0.069	- 0.181	0.500	-0.200,	0.200,	-0.111
∞	0.067	- 0.200				

Table 1. The q - factors vs. shell degeneracy for the SO_8 model in the first two columns and for the single-particle orbits in the remaining columns.

Hence we see that the absolute value of this factor is reduced in the SO_8 $u = 0$ subspace compared to the single-particle q-factors for the + phase convention. For the - phase convention it is reduced except for the orbit with the largest j. The amount of reduction depends on the phase convention.

3. CONCLUSION

We have shown that within the SO_8 model the expectation value of the spin operator in the subspace consisting only of $J^\pi = 0^+$, 2^+ pairs

4. REFERENCES

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2. Wu, C.L., Feng, D.H., Chen, X.G., Chen, J.Q. and Guidry, M. W., Phys. Lett. **B168**, 313 (1986).